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Greg

Dear Dr. Connally,

In response to your letter of April 3, transmitting the results of the Massachusetts Benchmarking Study of cigarette emissions for several brands stated to be a representative sample of those marketed in Massachusetts, and requesting my thoughts, I have the following comments. You asked 8 questions; regrettably, I have time only for a limited response.

I have performed a preliminary analysis of the sidestream (SS) cigarette emissions of TSP, nicotine, and CO for 12 brand styles said to be representative of the Massachusetts marketplace in 1998, based on the data tables in the study. Based on this analysis, it appears that emissions of these compounds are linearly dependent on the mass of tobacco burned. Therefore, to first approximation, one can predict the average emissions of these compounds into room air by simply assuming an average cigarette mass of 0.7 g of tobacco is burned. Figures 1,2, and 4 (attached) give the regression equations.

In question 7, you noted that the conditions for testing did not reflect a real world setting. This is correct; human exposures to environmental tobacco smoke (ETS) do not take place in a "fishtail chimney." However, the law of conservation of mass ensures that these emissions contribute to human exposures. The only question is in what form? It appears that TSP emissions average about 24 milligrams per cigarette (mg/cig). Since the cigarette companies' own data suggests that, weighted for market share, the top 50 brands of cigarettes emit 13.7 mg/cig of ETS-RSP (SE 0.4 mg/cig), where RSP refers to collection on a 1 micron filter [Martin, et al., 23:75-90 (1997)]. The differences between ETS-RSP and ETS-TSP suggest that nearly half of a cigarette's particulate emissions may appear in larger particle sizes than RSP or $PM_{2.5}$, perhaps as PM_{10}.

Since both PM_{10} and $PM_{2.5}$ are regulated air pollutants (where PM refers to particulate matter, and the subscript refers to the particle diameter in microns) with known exposure-response relationships to respiratory and cardiovascular disease, and whereas TSP refers to all particles in the air, including the non-respirable fraction above 10 microns, it would be very useful to be able to compare the TSP, PM_{10} and $PM_{2.5}$ fractions in ETS for the purposes of assessing human exposure and health risk to these regulated pollutants, and to understand where the SS mass goes for predictive (i.e., modeling) purposes. To do this under controlled "real world" conditions requires a ventilated environmental chamber. ETS measurements in an unventilated chamber have been described by Martin, et al.(1997), so that this could be easily done by the industry.

In question 8, you asked about predicting human exposure to nicotine and other toxic constituents. As figure 3 shows, SS TSP is strongly correlated to SS nicotine, with a ratio of about 6 to 1. SS nicotine is very likely nearly all in the particulate phase.

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However, ETS nicotine is almost entirely in the gas phase. It seems likely that most or all of the SS TSP remains in the particulate phase. A mass-balance study is necessary to understand this relationship. In any case, human exposure is to ETS. The ratio of ETS RSP to ETS nicotine in the Martin et al. (1997) study is about 9:1. Thus, to estimate human exposures to individual compounds, it is necessary to measure their ETS emissions, which was not done in the current Benchmark study.

I would also observe that since ETS nicotine is highly correlated to its metabolite, cotinine, and since both nicotine and cotinine can be correlated to human disease, it is of vital importance for human exposure assessment to develop reliable correlations between ETS nicotine and other ETS pollutants as well. To make this perfectly clear, I believe it is possible to predict not only ETS emissions, given the proper data, but human exposures to individual ETS pollutants and human risk of disease from the ETS mixture. I would urge the State of Massachusetts to consider ETS chamber measurements in the next phase of benchmarking. I would also suggest that persons experienced in these measurements at Harvard, Yale, Berkeley, and LBL be consulted as well as the industry.

Sincerely,

James L. Repace, MSc.
Physicist

Figures 1-4 follow.